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ANNUAL REPORT, 1988

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Northwestern Region

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TABLE OF CONTENTS

SUMMARY 1

INTRODUCTION 5

1.0 PURPOSE OF MONITORING PROGRAM 5

2.0 POLLUTANTS AND THEIR MEASUREMENT 6

2.1 Particulate Matter 6
2.2 Gaseous Pollutants 7
2.2.1 Carbon Monoxide (CO) 7
2.2.2 Nitrogen Oxides (NO_x) 8
2.2.3 Ozone (O_3) 8
2.2.4 Sulphur Dioxide (SO_2) 9
2.2.5 Total Reduced Sulphur (TRS) 9
2.3 Miscellaneous 9

RESULTS 10

3.0 ATIKOKAN 10

3.1 Ontario Hydro Generating Station 10
3.2 Proboard Limited 11

4.0 BALMERTOWN 12

4.1 Arsenic 12
4.2 Mercury 13
4.3 Sulphur Dioxide 13

5.0 DRYDEN 14

5.1 Lagoon 14
5.2 Kraft Pulp Mill 15
5.2.1 Particulate Matter 15
5.2.2 Odour Levels 15

6.0 FORT FRANCES 15

6.1 Vegetation Effects 16
6.2 Particulate Matter 16
6.3 Odour Levels 17

7.0 KENORA 18

7.1 Particulate Matter 18
7.2 Sulphation Rates 18

8.0 MARATHON 18

8.1 Particulate Matter 19
8.2 Odour Levels 19

9.0 RED ROCK 19

9.1 Particulate Matter 19
9.2 Odour Levels 20

10.0 SCHREIBER 20

10.1 Particulate Matter 20

11.0 TERRACE BAY 21

11.1 Odour Levels 21

12.0 THUNDER BAY 21

12.1 Particulate Matter 22
12.1.1 Dustfall 22
12.1.2 Suspended Particulate Matter and Soiling Index 22

12.2 Gaseous Pollutants 23
12.2.1 Carbon Monoxide, Nitrogen Dioxide and Ozone 23
12.2.2 Sulphur Dioxide 23
12.2.3 Total Reduced Sulphur 24

12.3 Special Studies 24
12.3.1 Albright and Wilson Americas 24
12.3.2 Thunder Bay Terminals Limited 24

ACKNOWLEDGEMENT 25

REFERENCES 26-28

FIGURES AND TABLES 29-53

SUMMARY

This report presents results of the Ministry's air quality assessment program for 1988 in northwestern Ontario. It includes data from 10 communities where long-term monitoring is conducted, plus summaries of special surveys in Thunder Bay.

ATIKOKAN

The Ministry and Ontario Hydro continued their monitoring programs around the 200-megawatt thermal generating station near Atikokan. During 1988, there were no exceedences of air quality objectives for sulphur dioxide, nitrogen dioxide or ozone.

Near the Proboard Limited particleboard plant, average dustfall complied with the provincial objective at three of four monitoring sites. Dustfall slightly exceeded the objective at one site.

BALMERTOWN

Arsenic persisted at elevated concentrations in vegetation on company property near two gold mines, but was near normal in the adjoining townsite. Arsenic levels generally declined from 1987 to 1988. All vegetable samples from residential gardens met guidelines for arsenic and mercury. In soil, arsenic levels throughout the study area remained high, and were little changed from a similar survey 10 years earlier.

During the growing season (May to September), hourly average sulphur dioxide exceeded the acceptable limit 19 times, compared with 23 occurrences in 1987, 28 in 1986, and 61 in 1985. This improvement is ascribed to better operating controls at the Campbell Red Lake Mine. There was visible vegetation injury caused by sulphur dioxide in a 9-hectare area on company property and in a 1-hectare zone off property. The company is reviewing options to modify its process methods to eliminate sulphur dioxide emissions.

DRYDEN

According to sulphation measurements, average odour levels near a secondary treatment system (lagoon) for kraft pulp mill effluent were low throughout the year.

The average level of suspended particulate matter in the town centre was satisfactory.

Odour levels in central Dryden continued the excellent trend of improvement recorded in recent years. The Ontario TRS guideline was exceeded only once in 1988.

FORT FRANCES

There was no off-property vegetation damage caused by air pollution around the local kraft pulp mill or near the mill's secondary treatment system (lagoon).

Average dustfall continued to exceed the Ministry objectives off mill property. Average suspended particulate concentrations, however, were acceptable. Improved emission controls on the mill's recovery boiler are expected to reduce particulate fallout in 1989.

Odour levels continued their recent worsening trend; the number of exceedences of the TRS guideline near the Fort Frances mill was 87 in 1985, 300 in 1986, 450 in 1987, and 552 in 1988. The emission source considered responsible for many of the high readings during the past 3 years will be controlled by mid-1989. Other odour controls are also being introduced.

KENORA

Some exceedences of the Ontario dustfall objective were recorded at one of the four monitoring sites near a sulphite pulp mill. The mill will be upgrading pollution controls on its power boiler system, which is the main source of particulate emissions.

MARATHON

Near a wood-chip storage area at a local kraft pulp mill, fallout of wood fines did not appear to cause a significant nuisance to area residents in 1988. There was general compliance with dustfall objectives.

Odour levels near the mill did not change much from 1986 and 1987; there were 109 exceedences of the TRS guideline.

An air emission inventory will be carried out by the mill in the summer of 1989. Sources not in compliance with emission regulations will be addressed in a new Control Order.

RED ROCK

Emissions from power boilers at the local kraft pulp mill caused occasional exceedences of the Ministry's dustfall objectives in 1988. These exceedences were not severe enough to warrant special abatement action.

Operating irregularities at the mill resulted in fairly frequent exceedences of the provincial TRS guideline. Work completed under a Control Order resulted in much reduced odour levels by the end of 1988.

SCHREIBER

A special survey revealed that dust from an ore concentrate transhipment area on CPR property resulted in elevated levels of cadmium, copper and zinc off railway property. An abatement program has been implemented by CP Rail.

TERRACE BAY

Air quality in Terrace Bay in 1988 improved slightly from 1987 to 1988; however, there were still more than a hundred TRS guideline exceedences in 1988. The exceedences were caused by continuing operating problems with the lime kiln at the local kraft pulp mill. These problems were resolved in late 1988; the current Control Order requires TRS guideline compliance by mid-1989.

THUNDER BAY

Average dustfall in Thunder Bay in 1988 was within the acceptable range at 8 of the 10 monitoring sites in the city. Particulate emissions from a local pulp mill caused dustfall at two sites to slightly exceed the Ontario objective.

Suspended particulate matter met the annual provincial objective at 5 of 6 sites monitored. The site not meeting the objective was temporarily impacted by construction activity. Soiling index levels were also acceptable at all times during the year.

Carbon monoxide, ozone and sulphur dioxide consistently met Ministry objectives in 1988. Nitrogen dioxide was above the maximum acceptable limit for 2 hours during the year. The TRS guideline near a kraft pulp mill was slightly exceeded during 5 hours.

INTRODUCTION

1.0 PURPOSE OF MONITORING PROGRAM

The Ontario Ministry of the Environment conducts an air quality assessment program throughout the province. Monitoring networks record outdoor concentrations of pollutants that may adversely affect human health, animal life, vegetation, and the use and enjoyment of property. These surveys document compliance with air quality objectives, and determine long-term air quality trends. The monitoring program identifies pollution sources and assesses the results of pollution control measures.

In northwestern Ontario, air quality surveys first began in 1963, to measure airborne dust in the City of Thunder Bay. In 1988, the regional monitoring network covered 10 communities, with nearly 100 monitoring devices. More than 20 different pollutants are measured, plus meteorological parameters. Ontario Hydro also has air quality networks in Thunder Bay and Atikokan.

Data from air quality and meteorological instruments are supplemented by vegetation, soil and snow sampling studies, and by predictions of pollutant levels with mathematical models.

Monitoring in the region is mostly conducted in urban areas and near industrial sources of air pollution (eg. mining, pulp and paper). Therefore, air quality problems described in this report are not typical of the region, where air quality is generally excellent.

Acid rain is a major environmental issue in eastern North America and in parts of Europe. Ontario, through its Acidic Precipitation in Ontario Study, is assessing the effects of acid fallout and is developing possible answers to this problem. The Ministry's Northwestern Region participates in this program through

precipitation sampling surveys at nine sites and through research on the aquatic, terrestrial, and biogeochemical effects of acid rain. The findings of these studies are reported elsewhere.

A major new development in the air quality program in northwestern Ontario was the installation of a telemetry system to greatly increase the speed with which data are received. This system was installed in late 1986. It permits the Ministry to obtain immediate readings from any continuous monitor in the region. Beginning in early June, 1988, an Air Quality Index (AQI) has been issued four times daily for Thunder Bay. The AQI is based on readings for six pollutants: carbon monoxide, ozone, nitrogen dioxide, particulate matter (soiling index), sulphur dioxide, and total reduced sulphur. By mid-1989, plans call for publication of an AQI for Fort Frances. Other communities may be added in future.

2.0 POLLUTANTS AND THEIR MEASUREMENT

Under this heading, only those contaminants routinely monitored in northwestern Ontario are considered. Hydrocarbons are not presently measured, nor are exotic organic compounds. If the need arises, many of the more unusual pollutants can be monitored with mobile equipment from the Ministry's Air Resources Branch, Toronto.

2.1 Particulate Matter

There are many man-made and natural sources of airborne particulate matter. Typical man-made sources in northwestern Ontario are forest product industries and mining operations. Wind-blown particles from stored materials and roadways are examples of secondary sources. Particulate matter may also be emitted from forest fires, volcanoes, and dust storms. Depending on particle size and chemical makeup, particulate matter may be harmful to health and vegetation, may adversely affect visibility, and may cause local nuisance problems. In Ontario, particulate matter is measured as dustfall, total suspended particulate matter (TSP), and soiling index.

Dustfall is particulate matter that settles out from the air by gravity. Open-top containers (dustfall jars) are exposed for 30-day periods and the collected matter is weighed.[1] The monthly air quality objective (maximum acceptable limit) for dustfall is 7 $g/m^2/30$ d (grams per square metre during 30 days). The annual objective is 4.6 $g/m^2/30$ d. Dustfall estimates the fallout of particulate matter from local sources, including dust from construction or from vehicles. It is rarely considered to be a health-related pollutant, but may cause a significant nuisance because of soiling effects.

Suspended particulate matter comprises particles of small size which remain entrained in the air for long periods. This material may come from local or distant sources. It is measured with a high-volume sampler for a 24-hour period every sixth day.[2] The difference in the weight of a fibreglass filter before and after exposure determines the quantity of particulate matter collected. The air quality objective is 120 $\mu g/m^3$ (micrograms per cubic metre of air sampled) averaged over 24 hours, and 60 $\mu g/m^3$, annual geometric mean.

Soiling index is a measure of the soiling or darkening properties of very small airborne particles and is expressed as coefficient of haze (COH). It is related to the concentration of respirable particulate matter. A measured volume of air passes through a paper tape which moves through an automated sampling unit to produce a reading every hour. The reduction of light transmitted through the tape is expressed as coefficient of haze (COH) per 1,000 linear feet of air sampled. The Ontario objective is 1.0 COH, 24-hour average, and 0.5 COH, annual average.

2.2 Gaseous Pollutants

2.2.1 Carbon Monoxide (CO)

Carbon monoxide is a colourless, odourless gas. Its primary

source (about 80%) is motor vehicles. A secondary source is fossil fuel combustion. As the number of vehicles in northwestern Ontario is small relative to other parts of the province, carbon monoxide is not a problem pollutant in this region. Elevated concentrations of carbon monoxide cause well-known health effects. The maximum acceptable level in Ontario is 30 ppm (parts of carbon monoxide per million parts of air), 1-hour average, and 13 ppm, 8-hour average. This pollutant is measured with a continuous analyzer[3] at one location in Thunder Bay.

2.2.2 Nitrogen Oxides (NO_x)

Nitric oxide (NO) and nitrogen dioxide (NO_2) are together termed nitrogen oxides (NO_x). Both NO and NO_2 may be emitted from natural and man-made sources. High-temperature fuel combustion, which occurs in vehicle engines and thermal power plants, is the main man-made emission source. At concentrations measured in ambient air, NO has no known adverse effects. NO may, however, oxidize to NO_2 which, in turn, may adversely affect health and visibility. NO_2 also reacts with hydrocarbons in sunlight to form ozone. It may also combine with water to form nitric acid, a component of acid rain. Nitrogen oxides are monitored with continuous analyzers.[4] The air quality objectives for NO_2 in Ontario are 0.2 ppm, 1-hour average, and 0.1 ppm, daily average.

2.2.3 Ozone (O_3)

Ozone occurs naturally and beneficially in the upper atmosphere. Near the ground, it is a product of reactions between nitrogen oxides and hydrocarbons. If present at high concentrations, it may adversely affect health and damage vegetation. Since ozone-forming compounds are not emitted in large amounts in northwestern Ontario, elevated ozone readings, if present, would suggest long-range transport from outside the region. Ozone is measured with continuous analysers,[5] and the current air quality objective is 0.08 ppm, averaged over one hour.

2.2.4 Sulphur Dioxide (SO_2)

Sulphur dioxide is one of the world's major atmospheric pollutants and has many well-known adverse effects on human health, vegetation and property. It is also one of the main contributors to acid rain. In northwestern Ontario, the principal SO_2 sources are small compared to those in some other parts of the province. The main regional emitters of SO_2 are, in approximate descending order of importance, Ontario Hydro generating stations (Thunder Bay and Atikokan), sulphite pulp mills, gold ore roasting, and industrial boilers. SO_2 may be measured with passive samplers (sulphation plates) to provide a semi-quantitative estimate of the presence of sulphur-containing gases. Results are expressed as monthly sulphation rates, in mg $SO_3/100\ cm^2/d$ (milligrams of sulphur trioxide per 100 square centimetres of treated filter paper per day). Sulphur dioxide is also monitored with continuous analyzers.[6] There are three air quality objectives for this pollutant: 0.25 ppm, hourly average; 0.10 ppm, 24-hour average; and 0.02 ppm, annual average.

2.2.5 Total Reduced Sulphur (TRS)

Total reduced sulphur comprises a group of sulphur-containing gases found in emissions from kraft pulp mills, which are the sole significant TRS sources in the region. At very low concentrations, TRS results in offensive odours. Higher levels may cause temporary discomfort to sensitive individuals. In Ontario, a guideline of 27 ppb (parts of TRS, expressed as hydrogen sulphide, per billion parts of air), averaged over one hour, is used as an air quality objective near kraft pulp mills. TRS may be measured with sulphation plates, for semi-quantitative results, or with continuous analysers.[7]

2.3 Miscellaneous

The occurrence and effects of some of the foregoing pollutants, plus others, may be assessed by vegetation injury and by determining

contaminant levels in vegetation, soil and snow. Standard Ministry procedures,[8,9,10] are followed in collecting and analysing these types of samples. Arsenic, chloride, fluoride,[11] sulphur and heavy metals are typical pollutants examined this way. Their levels in a study area are compared with normal background values at sites unaffected by pollution. Contaminant guidelines developed by the Ministry for vegetation, soil and snow are used in this report. The guidelines are based on "normal" elemental concentrations across the province. Exceedence of the guidelines would suggest that contamination may be present, but would not necessarily imply adverse effects.

Dustfall, sulphation, and suspended particulate matter determinations, as well as most analyses for vegetation, soil and snow, are carried out at the Ministry's Thunder Bay laboratory. The Ministry's Toronto laboratory analyses metals, nitrate, and sulphate in suspended particulate matter, and sulphur and halides (chloride, fluoride) in vegetation and soil. The Toronto laboratory also analyses unusual contaminants (e.g.: organic compounds such as PCBs or pesticides).

The Ministry's Air Resources Branch processes strip charts from continuous analyzers, and produces computer printouts of all air quality and meteorological data for the region. During 1988, routine reading of strip charts was phased out and replaced with data from the new air quality telemetry system. This system allows the Ministry's Thunder Bay and Kenora offices immediate access to all continuously monitored air quality data across northwestern Ontario.

RESULTS

3.0 ATIKOKAN

3.1 Ontario Hydro Generating Station

In 1981, the Ministry and Ontario Hydro began an air quality

assessment program around a lignite-fired generating station under construction near Atikokan. Ontario Hydro operates the air quality monitoring network and the Ministry collects precipitation, vegetation, soil, and snow samples at several sites (Figure 1).

By late 1985, when the 200-megawatt plant went into service, at least three years of background data had been collected. A summary report for the pre-operational terrestrial and atmospheric deposition studies was issued in 1986.[12]

The Ministry and Ontario Hydro continued their monitoring programs during 1986, 1987 and 1988, the first three operational years for the power plant. Ontario Hydro's environmental quality compliance reports show that no exceedences of Ontario's air quality objectives for sulphur dioxide, ozone, or nitrogen dioxide were recorded during this period. A report on 1986 atmospheric deposition and terrestrial data revealed no significant changes from the pre-operational period.[13] The terrestrial studies concluded in 1988; re-sampling is scheduled for 1992. The atmospheric deposition program will continue unaltered for the time being.

In 1988, at the Ministry's long-term monitoring site in the Town of Atikokan, all but one of the 53 TSP samples met the 24-hour air quality objective of 120 $\mu g/m^3$. The annual geometric mean of 26 $\mu g/m^3$ also complied with the limit of 60 $\mu g/m^3$, and was similar to values for preceding years.

3.2 Proboard Limited

A small 4-station network (Figure 2) was established in October, 1987, to monitor dustfall near Proboard Limited (formerly Pluswood Manufacturing Limited). This company produces particleboard. In 1988, monthly dustfall exceeded the Ministry objective in 6 of 47 samples. Annual average dustfall was acceptable at three sites and slightly above the objective of 7.0 $g/m^2/30$ days at station 62064. The 1988 data did not indicate a fallout problem in the residential area near Proboard.

4.0 BALMERTOWN

The Ministry has conducted air quality surveys near two gold mines in Balmertown since 1971. For many years, Campbell Red Lake Mines Limited, and the Dickenson-Sullivan Joint Venture, Arthur W. White Mine (formerly Dickenson Mines Limited), emitted significant amounts of airborne arsenic trioxide and sulphur dioxide from ore roaster stacks. In the mid-1970's, both mines reduced arsenic emissions by more than 95%. In early 1980, Dickenson shut down its roaster.

4.1 Arsenic

In 1988, arsenic concentrations in leaves of trembling aspen trees at 17 sites near the mines (Figure 3) remained elevated on company property but were near normal levels in the townsite. The elevated arsenic on company property is ascribed to localized fugitive emissions from arsenic-containing wastes or from concentrates. Stack emissions may also contribute to arsenic fallout. Table 1 compares arsenic readings for the past 5 years at selected sites on and off company property. Table 2 presents data for the same period from planted roadside trees in the townsite. Both tables show that current arsenic levels in tree vegetation in the townsite are above normal background concentrations. Apart from sites 13 and 14 on Dickenson's property (Table 1), arsenic concentrations were lower in 1988 than in 1987.

For the first time since 1978, surface soils were collected at all sampling sites. Arsenic in these samples was found to be still very high, but on average slightly lower in 1988 than in 1978. On-property levels ranged from about 200 to 3000 μg/g in the top 5 cm of soil, while arsenic in surface soil in the townsite varied from about 100 to 800 μg/g.

Arsenic in garden vegetables was below the former limit (approximately 10 μg/g, dry weight) specified by the Health

Protection Branch, Canada Department of Health and Welfare (Table 3). Because arsenic in garden soil remains high, Balmertown residents have been advised to thoroughly wash vegetables from their gardens.

4.2 Mercury

Because mercury is still used in ore processing at Dickenson, and was used at Campbell until 1982, the Ministry regularly examines mercury levels in the local environment. Mercury slightly exceeded the Ministry's contaminant guideline (0.1 μg/g) in trembling aspen leaves at one site on Dickenson's property, but was normal elsewhere. All vegetable samples from residential gardens met the recommended international guideline for mercury (0.5 μg/g, dry weight).

Mercury in surface soil on mine property and in the townsite changed very little from 1978 to 1988; on-property values in 1988 ranged from 0.1 to 2.3 μg/g, while in the townsite mercury was below 0.2 μg/g. The contaminant guideline for mercury is 0.15 μg/g for rural soil and 0.5 μg/g for urban soil.

4.3 Sulphur Dioxide

Sulphur dioxide sometimes exceeds desirable levels in Balmertown. In 1988, the Ministry's Balmertown monitor recorded 53 hourly SO_2 readings and two, 24-hour averages which exceeded acceptable levels. The maximum hourly average was 0.69 ppm, nearly three times the Ontario objective. The annual average (0.008 ppm) was satisfactory. In 1988, there was visible sulphur dioxide injury to vegetation in a small area of about 1.3 hectares off Campbell's property to the southeast of the roaster. Vegetation damage caused by SO_2 was also found in an area of about 9 hectares on Campbell's property east-northeast of the roaster stack.

During the growing season (May to September), SO_2 was above the acceptable hourly limit 19 times, compared with 23 occasions in 1987, 28 in 1986, and 61 in 1985. Table 4 summarizes the data for the past 5 years. The decline in exceedences over the past few years is attributed to improved application of a voluntary emission reduction program at the Campbell Red Lake mine. Under this abatement program, the company shuts down its ore roaster when the wind carries roaster-stack emissions over the townsite during the growing season. For the long term, the company is investigating process changes to eliminate the need for roasting.

5.0 DRYDEN

For several years, the Ministry has monitored air quality near a bleached kraft pulp mill and adjacent chlor-alkali plant in Dryden. Abatement action, process changes, and mill modernization have resolved most of the air quality concerns of the 1970's and early 1980's. Currently, the Ministry monitors odour levels in the town centre, and measures sulphation rates around the mill's secondary treatment system (lagoon). In July, the mill owners, Canadian Pacific Forest Products Limited (formerly Great Lakes Forest Products Ltd.), concluded a one-year survey of suspended particulate matter in the town centre.

5.1 Lagoon

A secondary treatment system (lagoon) was constructed in late 1983 to process effluent from the Dryden mill. Initially, wind-blown foam and odours from the lagoon caused a nuisance to area residents. The foam problem has now been resolved. Special Ministry studies in 1985 found no evidence of potential health effects from airborne substances near the lagoon.[14] Measurements from eight sites (Figure 4) revealed very low sulphation rates throughout 1988, as in 1987. Nearly 90% of the values were below the detection limit. These results indicate that average monthly odour levels around the lagoon were low during the year. Sulphation measurement was discontinued in December.

5.2 Kraft Pulp Mill

5.2.1 Particulate Matter

With one exception, TSP concentrations recorded in the town centre complied with the provincial objective between July, 1987 and July, 1988. One elevated reading, the cause of which is unknown, was obtained in mid-October. The annual mean TSP was 26 $\mu g/m^3$, well within Ontario's maximum acceptable limit of 60 $\mu g/m^3$.

5.2.2 Odour Levels

Offensive odours caused by reduced sulphur compounds are monitored with a continuous TRS analyzer in central Dryden (station 61027, Figure 4). As Table 5 shows, air quality in 1988 continued the commendable trend of improvement shown in recent years. The provincial guideline for TRS was exceeded only once, due to a brief operating problem at the mill.

6.0 FORT FRANCES

During its first few years of operation, emissions from a bleached kraft pulp mill in Fort Frances resulted in particulate fallout and odour problems in a nearby residential area. In the late 1970's, some emission reductions were achieved. In 1980, a Control Order was issued for further pollution controls. The mill also created a "buffer zone" through purchase of adjacent residential land.

Air quality studies in Fort Frances have been conducted regularly since 1972 near the Canadian mill, and periodically since 1974 around a similar plant owned by the parent corporation on the U.S. side of the border nearby (Figure 5).

6.1 Vegetation Effects

In 1988, there was no visible air pollution injury to vegetation inside or outside the buffer zone around the Fort Frances mill. The condition of trees which had suffered damage in past years was mostly unchanged from 1987, with a few individuals showing slight improvement. Sodium in tree foliage was low in 1988 samples (Table 6), possibly because of wash-off caused by heavy rain a few days before the sampling date. For this reason, and because it applies only for the growing season, vegetation analysis is not as reliable as dustfall measurements for determining fallout of saltcake (sodium sulphate) emitted from the mill. The decline in foliar chloride levels during the past few years (Table 6) suggests that emissions of chlorine and chlorine compounds from the mill may also have decreased.

There was no visible off-property damage to vegetation around the secondary effluent treatment system on Eighth Street (Figure 6).

6.2 Particulate Matter

Dustfall results for 1988 are summarized in Table 7. As in former years, the annual air quality objective for dustfall was met at only the two most distant sites from the mill (stations 62032 and 62037). On-property dustfall averaged more than twice the objective. Dustfall in the nearby residential area (excluding the two most distant sites) averaged 67% above the objective. Wood fibres accounted for about 25 to 75% of total dustfall when high dustfall readings occurred at these sites (stations 62034, 62035, 62036 and 62050). Saltcake comprised about 15% of total dustfall in this area. Road dust, fly ash, and insect parts were also sometimes present in significant amounts in dustfall, mainly during the summer. A comparison of average dustfall during recent years (Table 8) shows a trend of moderate decline, which is encouraging. The recently completed enlargement and rebuilding of the recovery boiler precipitator at the Fort Frances kraft mill should significantly reduce fallout of saltcake.

In 1988, total suspended particulate matter (TSP) was at the low end of the range recorded in recent years. The annual average TSP at the monitoring site near the mill (station 62035) was 51 $\mu g/m^3$, which met the provincial objective. Only 4 of the 54 daily readings at this site exceeded the 24-hour objective, the lowest number of exceedences to date. Highest levels occurred with south to southwest wind, when the monitor was downwind of the mill. The annual average TSP at the Fort Frances cemetery (station 62032) was 26 $\mu g/m^3$, which is normal for this location and well within the Ontario objective. There were no exceedences of the daily objective at this site.

6.3 Odour Levels

Sulphation rate averages in Fort Frances have been very stable during the past few years (Table 9). The number of exceedences of the TRS guideline increased from 1987 to 1988 (Table 10), continuing a trend which began in 1985. Figure 8 shows that the Fort Frances mill was the main source of elevated TRS at stations 62030 and 62052 (Church and Portage). At the cemetery monitoring site (station 62032), the International Falls mill was the source of most of the TRS.

The failure of a scrubber at the tall oil plant at the Fort Frances mill is suspected to be the main cause of increased odour levels in 1987 and 1988. A new scrubber is scheduled for installation in June, 1989. Other planned odour control includes condensate stripping , to be in place by the spring of 1990. Odour controls are also being upgraded at the International Falls pulp mill in the summer of 1989.

The Ministry will have two more TRS monitors in service in Fort Frances by the summer of 1989. These monitors will provide better coverage of the town and will help identify more accurately the sources contributing to the odour problem. Data from the monitoring station near the Civic Centre will be published daily as an Air Quality Index (AQI) starting in mid-1989.

7.0 KENORA

For many years, the Ministry has monitored air quality near a sulphite pulp mill in Kenora. The current monitoring program includes dustfall and sulphation measurements at four locations (Figure 8).

7.1 Particulate Matter

As Table 11 shows, average dustfall in Kenora in 1988 was similar to levels found in preceding years. Dustfall most frequently exceeded the monthly objective at station 61007, just north of the mill. Highest dustfall occurred in the spring and summer. Wood or bark char and woodfines were major components of dustfall when elevated readings occurred. Although the mill complies with emission regulations for particulate matter, unavoidable discharges during boiler start-up and shutdown cause nuisance fallout from time to time. Recently, the mill decided to proceed with a $4.5 million installation of a new precipitator to control particulate emissions from its boiler system.

7.2 Sulphation Rates

Average sulphation rates in 1988 were slightly higher than those in 1987 (Table 12), but this difference is not significant. As a result of a successful abatement program, there has been no evidence of a sulphur dioxide problem near the mill for several years. Sulphation measurements were terminated in December.

8.0 MARATHON

The Ministry currently maintains five air quality monitoring stations in Marathon (Figure 9) and one in Heron Bay. The purpose of the Ministry's assessment program is to monitor odour levels near the kraft pulp mill operated by James River-Marathon, Ltd. The company also has dustfall jars at five sites to measure fallout of particulate matter near a storage area for wood chips.

8.1 Particulate Matter

The fallout of wood fines from wood-chip piles near the pulp mill ("wood storage area", Figure 9) has been studied by the company and by the Ministry.[15] Dustfall measurements for 1988 by the company indicates general compliance with dustfall objectives at sites off company property. A few elevated readings occurred at one site during the summer. Steps have been taken to reduce dust emissions from the chip piles.

8.2 Odour Levels

Table 13 shows that average sulphation levels in the townsite have fluctuated in a narrow range during the past 5 years. Average annual TRS (Table 14) and the number of guideline exceedences increased slightly from 1987. To alert the mill when community odour levels exceed the desirable limit, the company telemeters TRS readings from the Ministry's monitor to the mill. The mill will be carrying out another emission inventory during the summer of 1989. Any sources identified by the inventory as not in compliance with regulations will require further abatement action, and will be addressed in a new pollution Control Order.

9.0 RED ROCK

The Ministry operates a small air quality monitoring network in the Town of Red Rock to measure dustfall and odour levels near a kraft pulp mill. The network comprises four dustfall jars at stations 63080 to 63083, and a continuous TRS analyser at station 63084 (Figure 10).

9.1 Particulate Matter

Table 15 summarizes dustfall in Red Rock for the past 5 years. During this time, average dustfall in the townsite has varied but there has been no clear trend. In 1988, one of the three monitoring

sites off mill property met the annual air quality objective; dustfall at the other two sites was slightly above the desirable limit. Most of the infrequent exceedences of the monthly objective were caused by wood or bark char, or by wood fines.

9.2 Odour Levels

There were 173 exceedences of the TRS guideline in 1988, slightly fewer than in 1987 (Table 16). Since 1982, when a new recovery furnace was installed at the pulp mill, community odour levels have fluctuated widely. In 1988, some of the exceedences of the TRS guideline occurred during scheduled or unscheduled shutdowns of the lime kiln, where odourous non-condensable gases (NCG) are burned. Under the present Control Order, the TRS guideline must be consistently met by the end of 1988. To achieve compliance, the company has improved its steam stripping and NCG system. Emission monitoring for TRS is also being carried out.

10.0 SCHREIBER

Some residents of Schreiber have expressed concerns about dust emissions from a transhipment facility on CP Rail property. The facility receives ore concentrate from a base metal mine 20 km northwest of Schreiber. The ore concentrate was handled at a temporary site from January to August, 1988, and thereafter at a permanent location.

10.1 Particulate Matter

Ministry surveys in 1987 and 1988 showed that fallout of dust from the transhipment area resulted in significantly elevated copper and zinc in moss samples exposed off company property. Cadmium was slightly above the Ministry guideline. Details of these findings are reported elsewhere.[16] A snow sampling study in early 1989 (report in preparation) showed similar results.

11.0 TERRACE BAY

The Ministry's monitoring program in Terrace Bay is directed toward measurement of odour levels in the townsite and at three points where an effluent ditch from the local kraft pulp mill crosses the TransCanada Highway (Figure 11).

11.1 Odour Levels

Average sulphation rates were slightly higher in 1988 than in 1987 (Table 17), but this difference was not significant. TRS data (Table 18) showed that air quality improved slightly from 1987 to 1988, but there were still more than a hundred exceedences of the TRS guideline. Operating problems with the lime kiln at the Kimberly-Clark mill occurred frequently in 1987 and 1988, resulting in frequent discharges of odourous gases. This problem was resolved in December, 1988, and community odour levels have improved since then. The current Control Order calls for compliance with the TRS guideline by June, 1989.

In late 1987, Kimberly-Clark decided to install a secondary treatment system ("lagoon") for liquid effluent from the pulp mill. To document concerns about odours from the lagoon, the Ministry installed a TRS monitor at station 63093 (see Figure 11) to collect data on pre-operational conditions. The lagoon is scheduled to be in service by October, 1989.

12.0 THUNDER BAY

The Ministry maintains a 10-station air quality monitoring network in Thunder Bay. The locations of these sites, plus those operated by Ontario Hydro, are shown in Figure 12. Thunder Bay's first "full" air monitoring station (63200) was placed in service on South James Street in late 1986. At this station, sulphur dioxide, ozone, carbon monoxide, nitrogen oxides, particulate matter (soiling index) and total reduced sulphur are continuously recorded. Three

of the Ministry's Thunder Bay monitoring stations (63005, 63022 and 63200) are part of Environment Canada's National Air Pollution Surveillance network. Ontario Hydro operates five sulphur dioxide monitors in Thunder Bay. It also has dustfall jars on and near its Mission Island property to measure dust from flyash disposal and coal storage areas around its power plant. The following discussion reviews air quality data from the Thunder Bay area, and includes brief summaries of some special studies carried out during the year.

12.1 Particulate Matter

12.1.1 Dustfall

Dust emitted from grain elevators was formerly a nuisance to Thunder Bay residents. Dustfall measurements near the elevators began in 1970, and the monitoring network has been revised periodically since then. The 1988 data for the 10 sites now in service are summarized in Table 19. During the year, average dustfall was below the maximum acceptable limit at 8 of 10 sites.

At Totem Trailer Court (site 63047) and at Montreal Street (station 63046), near Canadian Pacific Forest Products (formerly Great lakes Forest Products), average dustfall slightly exceeded the maximum desirable level. Flyash and bark or wood char were the main contributors to the elevated monthly readings at these sites. Average dustfall in Thunder Bay has met the Ministry objective since the late 1970's.

12.1.2 Suspended Particulate Matter and Soiling Index

Total suspended particulate matter was generally very satisfactory throughout Thunder Bay in 1988 (Table 20). About 96 percent of the total samples from all six monitoring sites were below the 24-hour maximum acceptable limit of 120 $\mu g/m^3$. Eleven of the 14 exceedences of this limit occurred at station 63046 (Montreal Street). The high readings at this site were caused mainly by dust

from nearby road and sewer construction work. The annual objective was met at all locations except Montreal Street.

Filters from the two city-centre stations (stations 63005 and 63022) had acceptable concentrations of heavy metals, including lead. Levels of sulphate and nitrate, which are influenced by long-range transport, varied considerably in 1988.

At station 63200, soiling index met the daily and annual air quality objectives.

12.2 Gaseous Pollutants

12.2.1 Carbon Monoxide, Nitrogen Dioxide and Ozone

Throughout the year, carbon monoxide was well below the maximum acceptable limit for 1-hour and 8-hour averages at station 63200. Nitrogen dioxide met the 24-hour objective but exceeded the hourly objective during 2 hours. Ozone did not exceed the provincial 1-hour objective of 0.08 ppm in Thunder Bay. However, at Hawkeye Lake, 40 km north-northwest of Thunder Bay, ozone levels were above the acceptable limit during 4 hours in May, 4 hours in June, and 2 hours in July. The maximum hourly average was 0.095 ppm at Hawkeye Lake. Ozone, a long-range transport pollutant, is not currently considered a problem in northwestern Ontario.

12.2.2 Sulphur Dioxide

The principal industrial sources of sulphur dioxide in Thunder Bay are a 310-megawatt lignite-fired generating station and four pulp and paper mills. Collectively, these sources are relatively small; total SO_2 emissions in Thunder Bay are less than 100 metric tons per day. The network of seven SO_2 monitors (five belonging to Ontario Hydro and two owned by the Ministry) showed full compliance for all SO_2 air quality objectives in 1988 (Table 22).

12.2.3 Total Reduced Sulphur

At the Ministry's Montreal Street monitoring site (station 63046), there were five minor exceedences of the TRS guideline in 1988 (Table 23).

12.3 Special Studies

12.3.1 Albright and Wilson Americas

A snow sampling survey (report in preparation) was carried out near Albright and Wilson Americas, which manufactures sodium chlorate for the pulp and paper industry. The plant was found to be a minor source of airborne chloride, chromium and sodium. These data confirm results from an earlier vegetation study. There was no evidence that emissions from the plant were causing an environmental problem; no abatement action was recommended.

12.3.2 Thunder Bay Terminals Limited

A report on 1988 air quality monitoring near Thunder Bay Terminals Limited[17] showed that this facility continued to operate satisfactorily. Western coal and potash are the main products handled. There has been no increase in dust levels at off-property monitoring sites since shipments began in 1978.

ACKNOWLEDGEMENT

The assistance of staff of the Atmospheric Environment Service, Atikokan Weather Station, for operating a high volume sampler is gratefully acknowledged.

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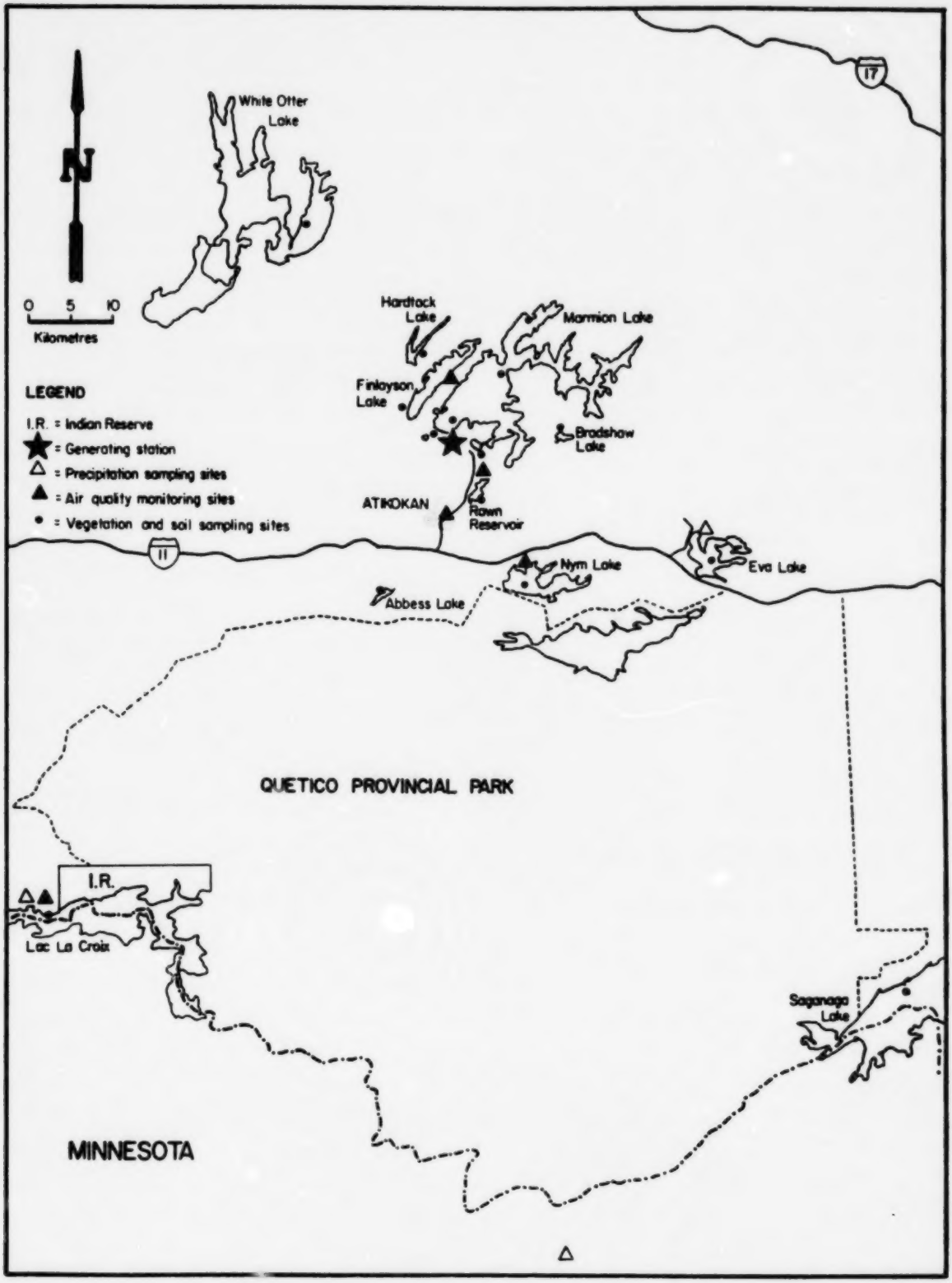

Figure 1. Air quality assessment sites, Ontario Hydro generating station, Atikokan.

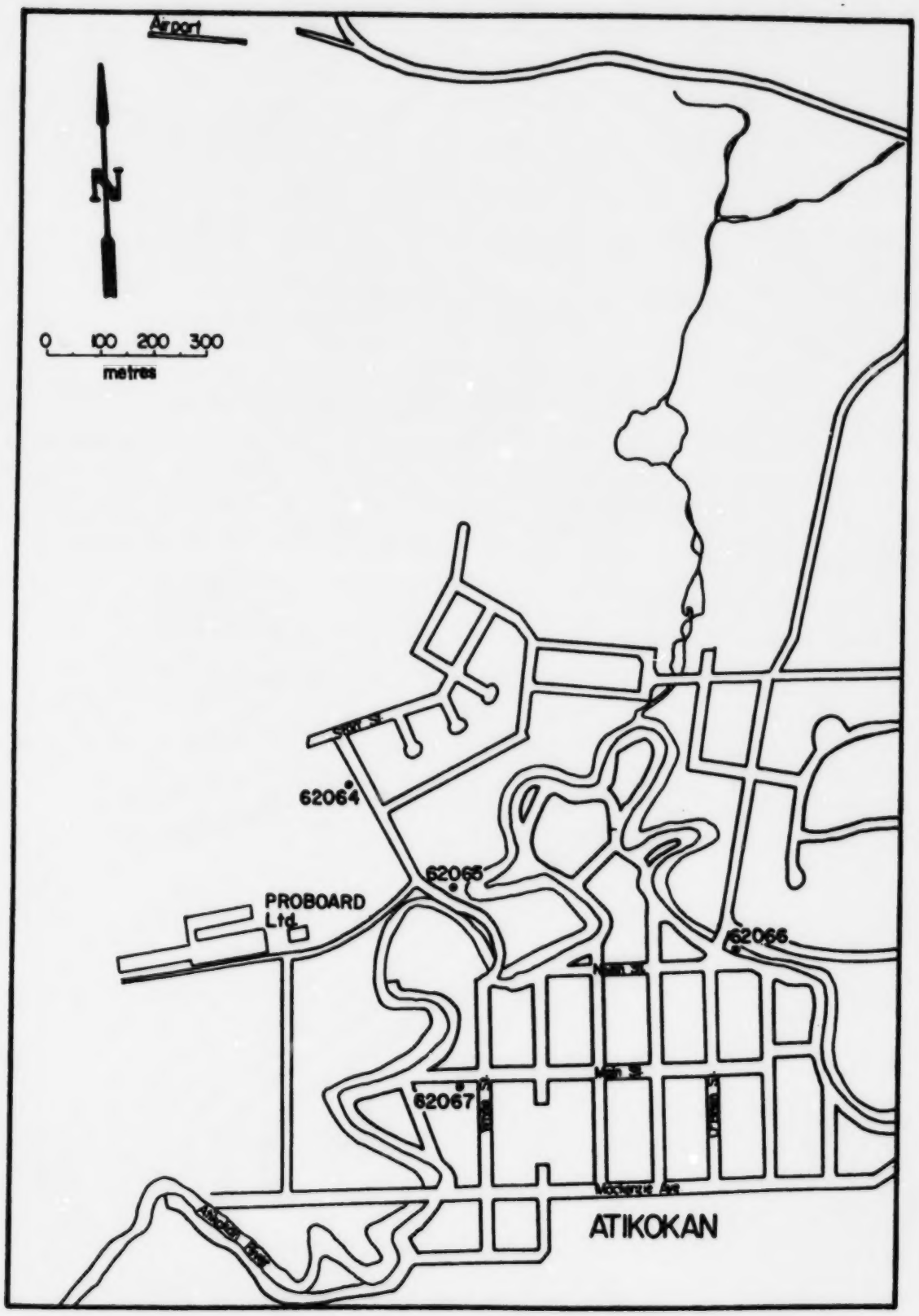

Figure 2. Air quality monitoring sites near Proboard Ltd., Atikokan.

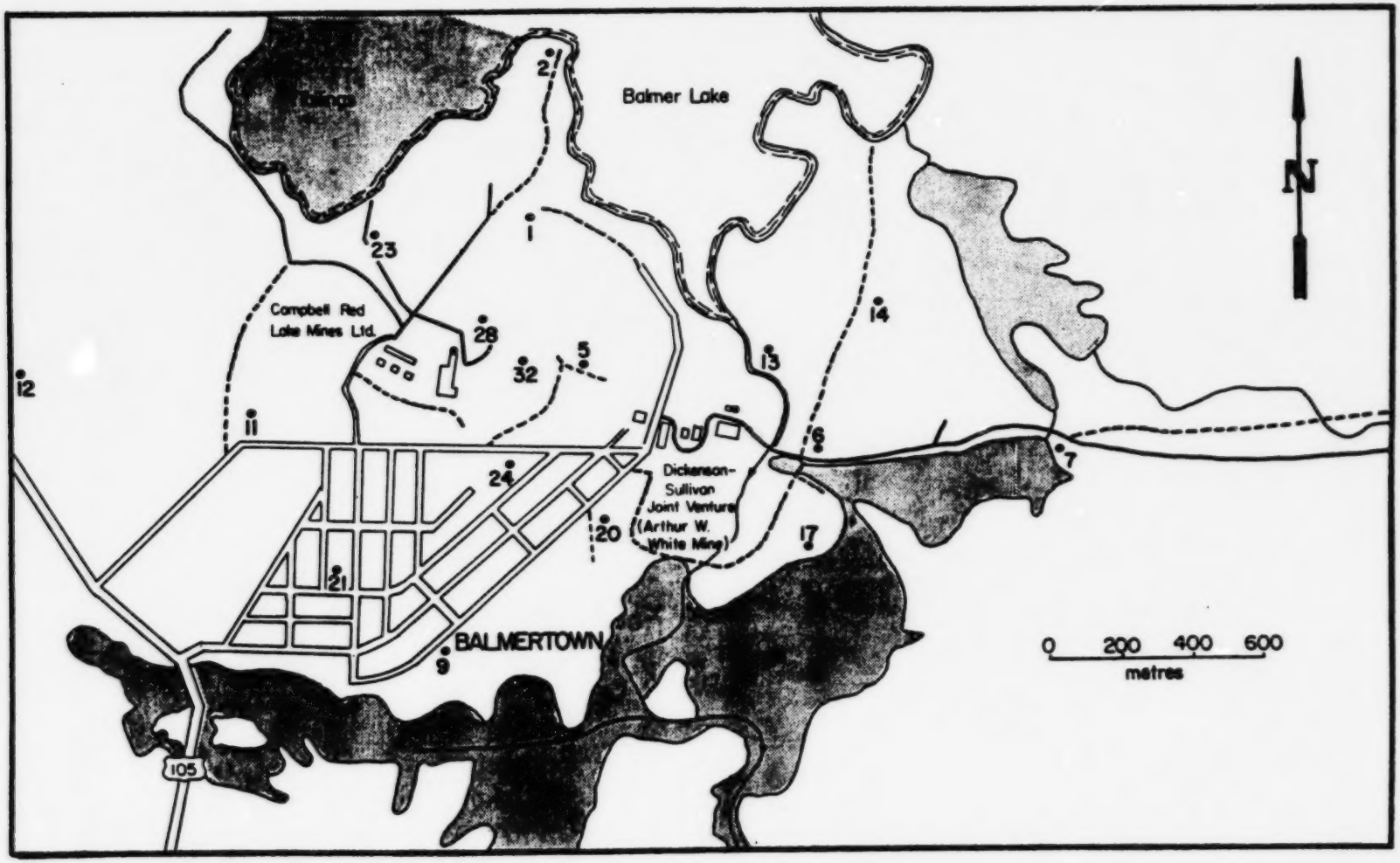

Figure 3. Trembling aspen sampling sites, Balmertown.

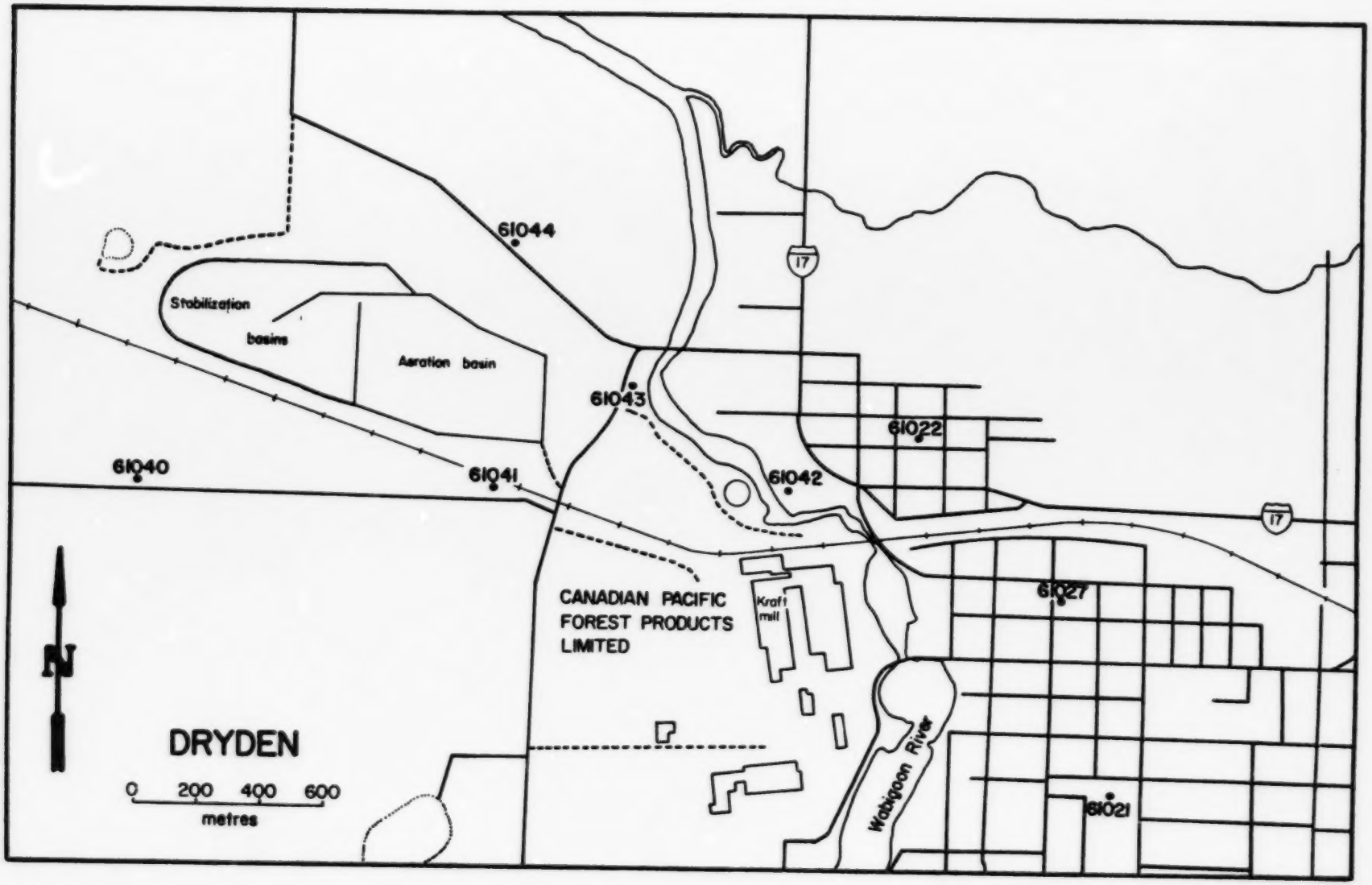

Figure 4. Air quality monitoring sites, Dryden.

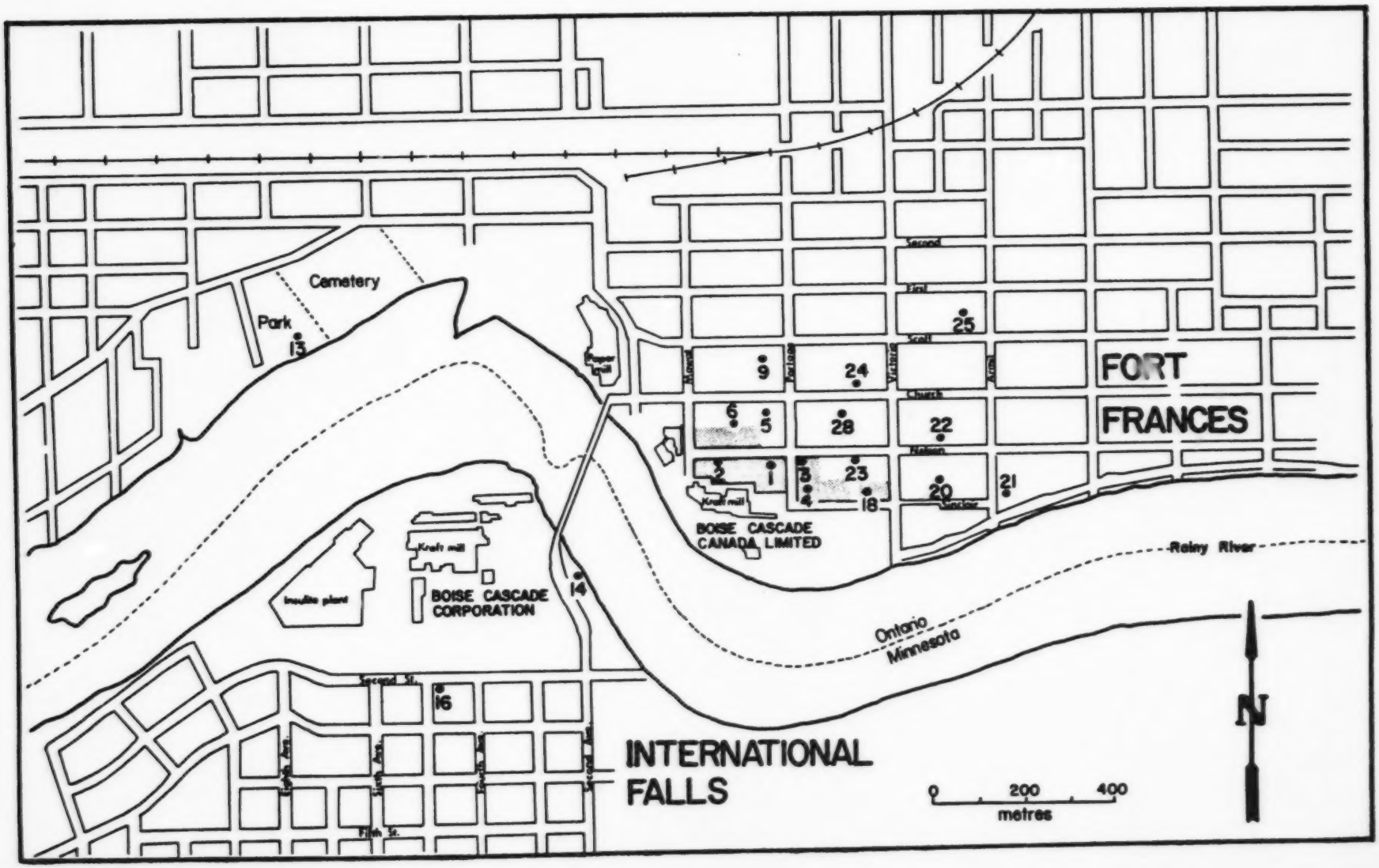

Figure 5. Manitoba maple sampling sites, Fort Frances.

Buffer zone

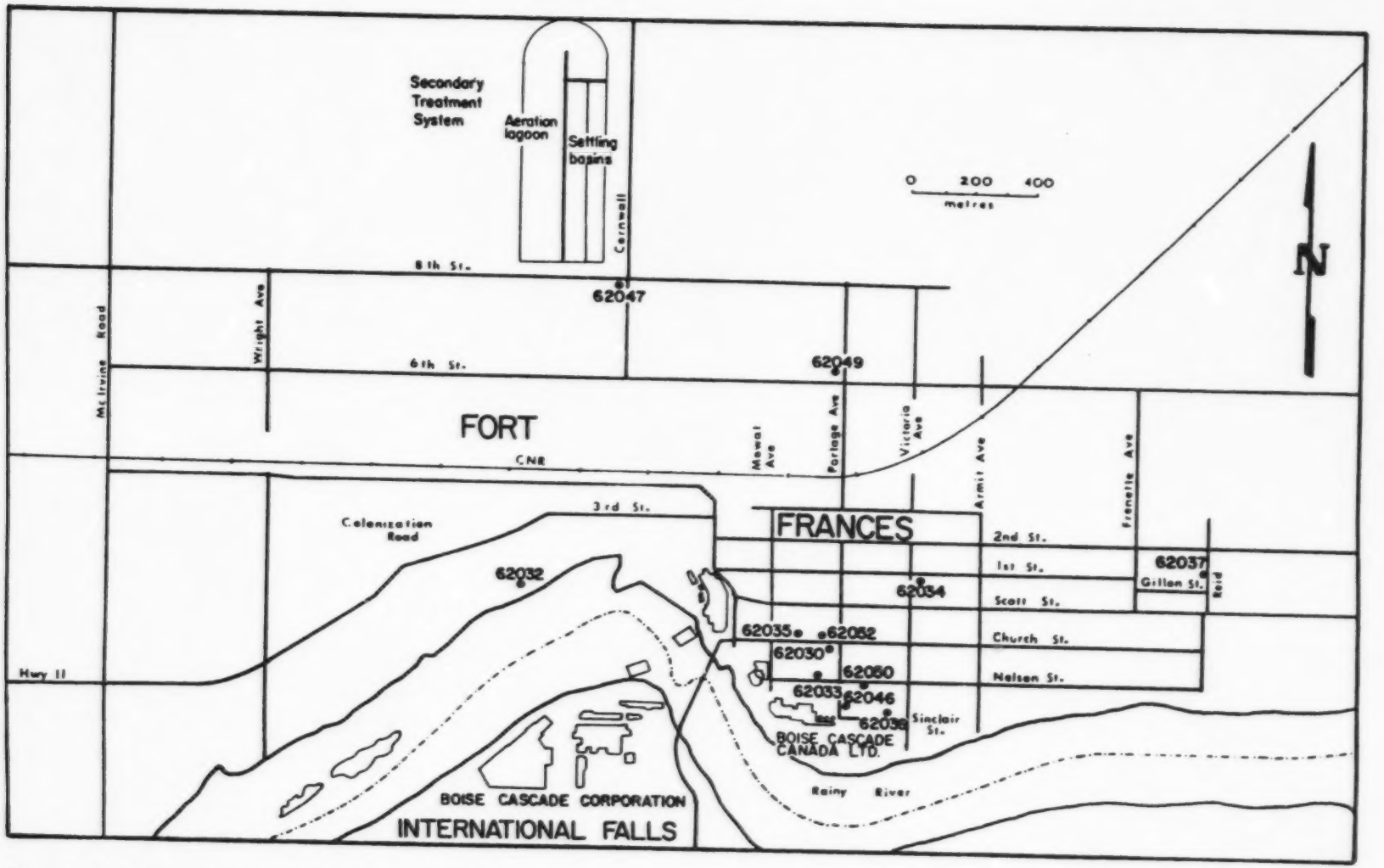

Figure 6. Air quality monitoring sites, Fort Frances.

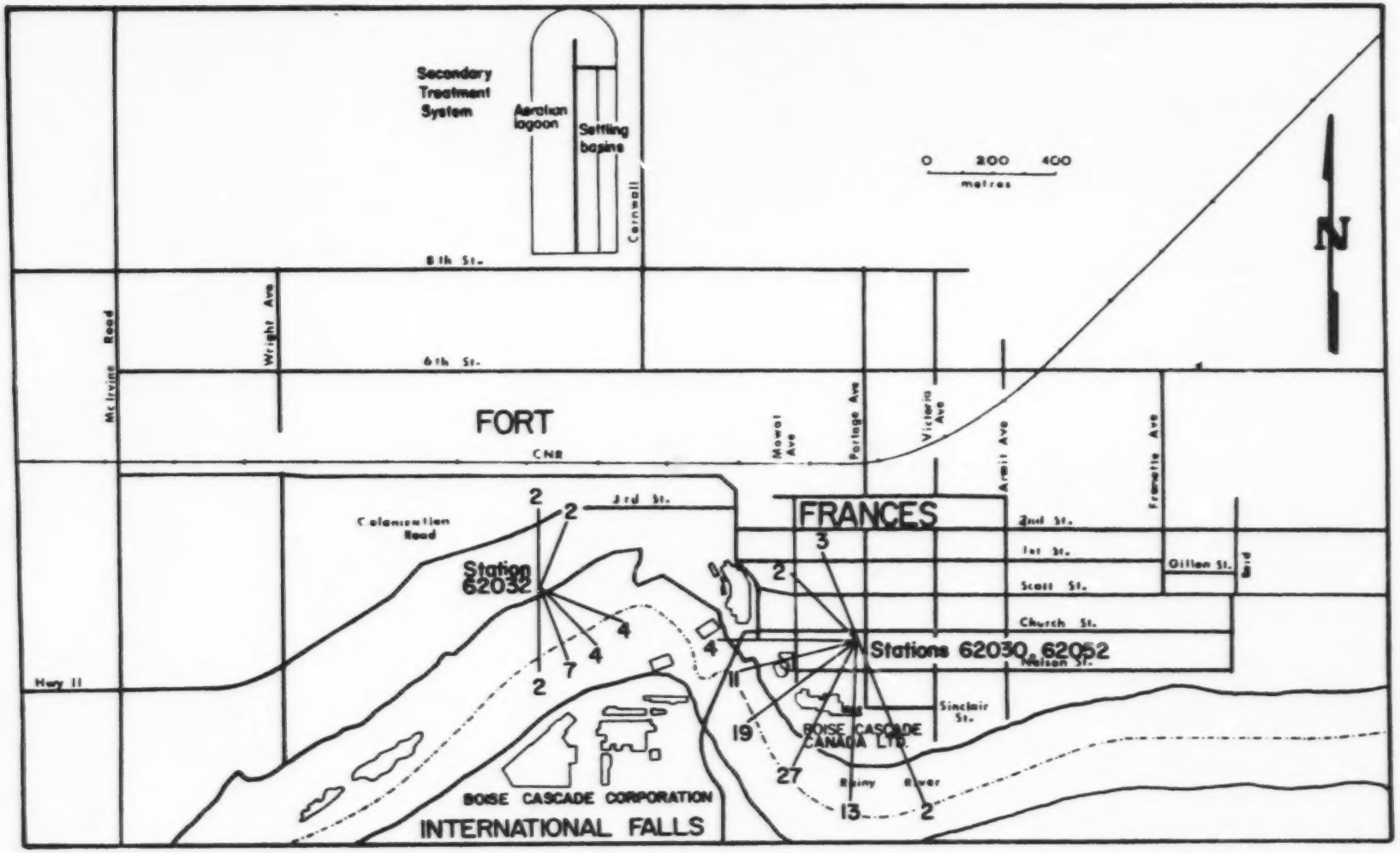

Figure 7. Average 1988 TRS levels (ppb) associated with wind directions indicated (only averages of 2 ppb or greater are shown).

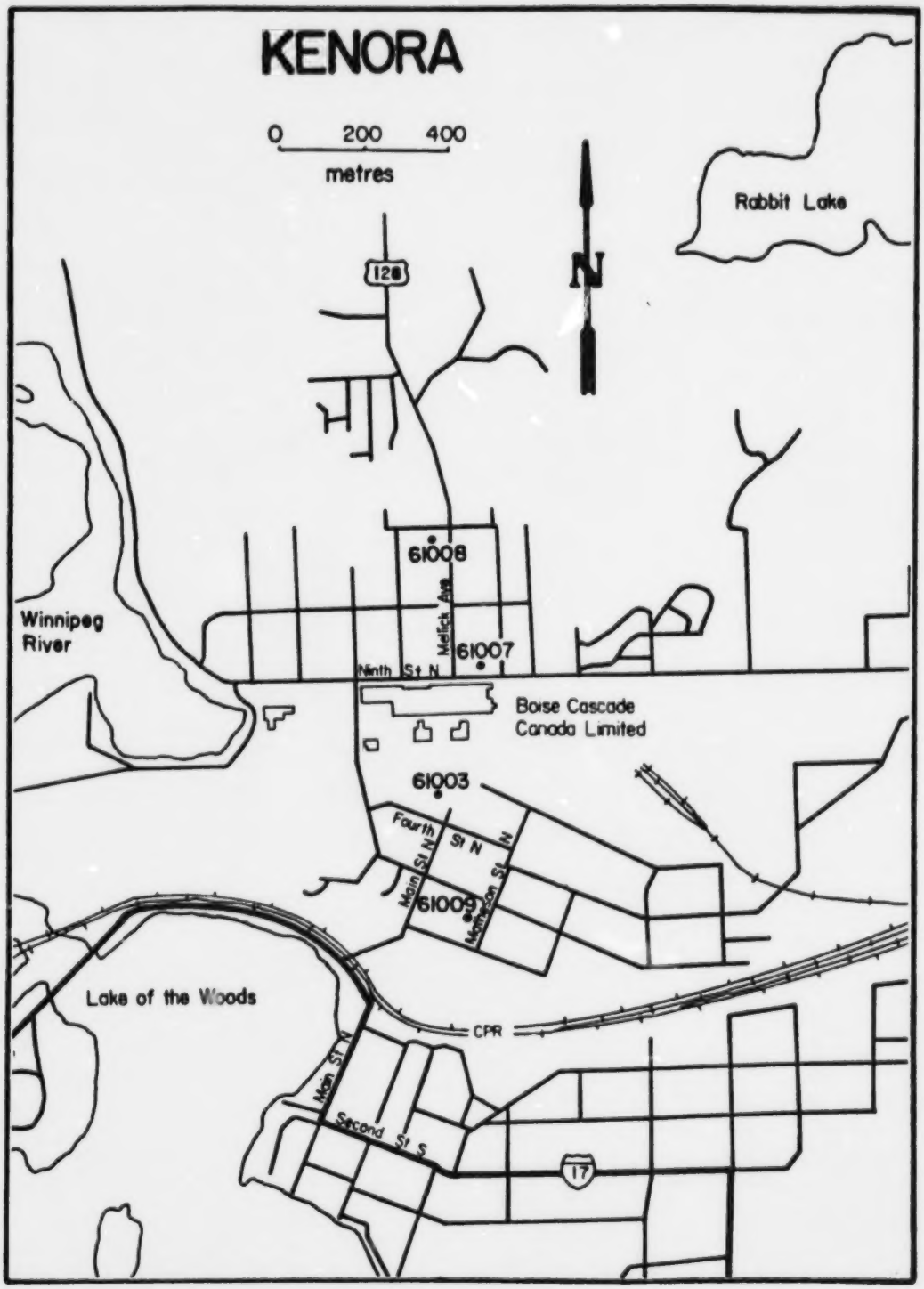

Figure 8 . Air quality monitoring sites, Kenora.

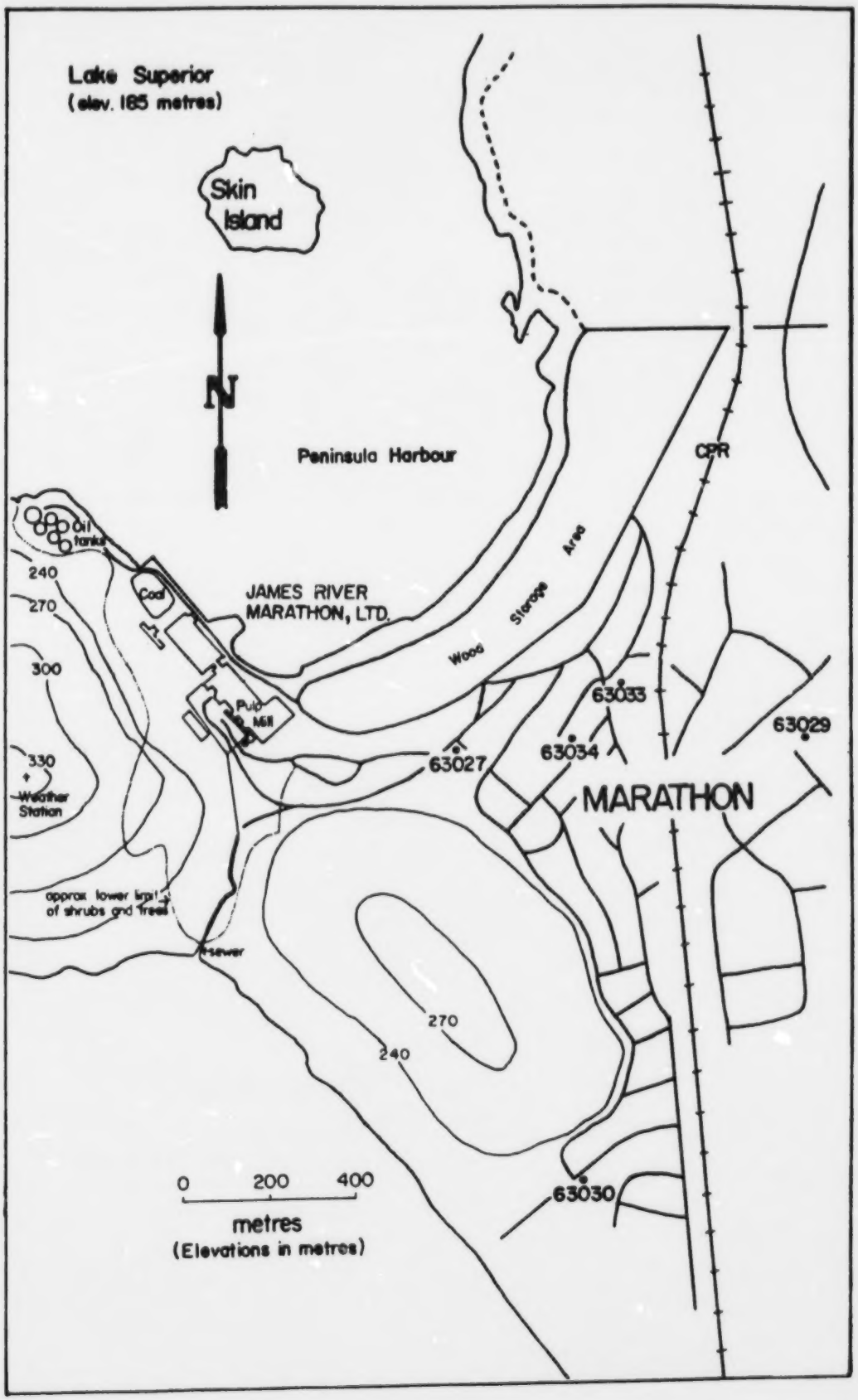

Figure 9 . Air quality monitoring sites, Marathon.

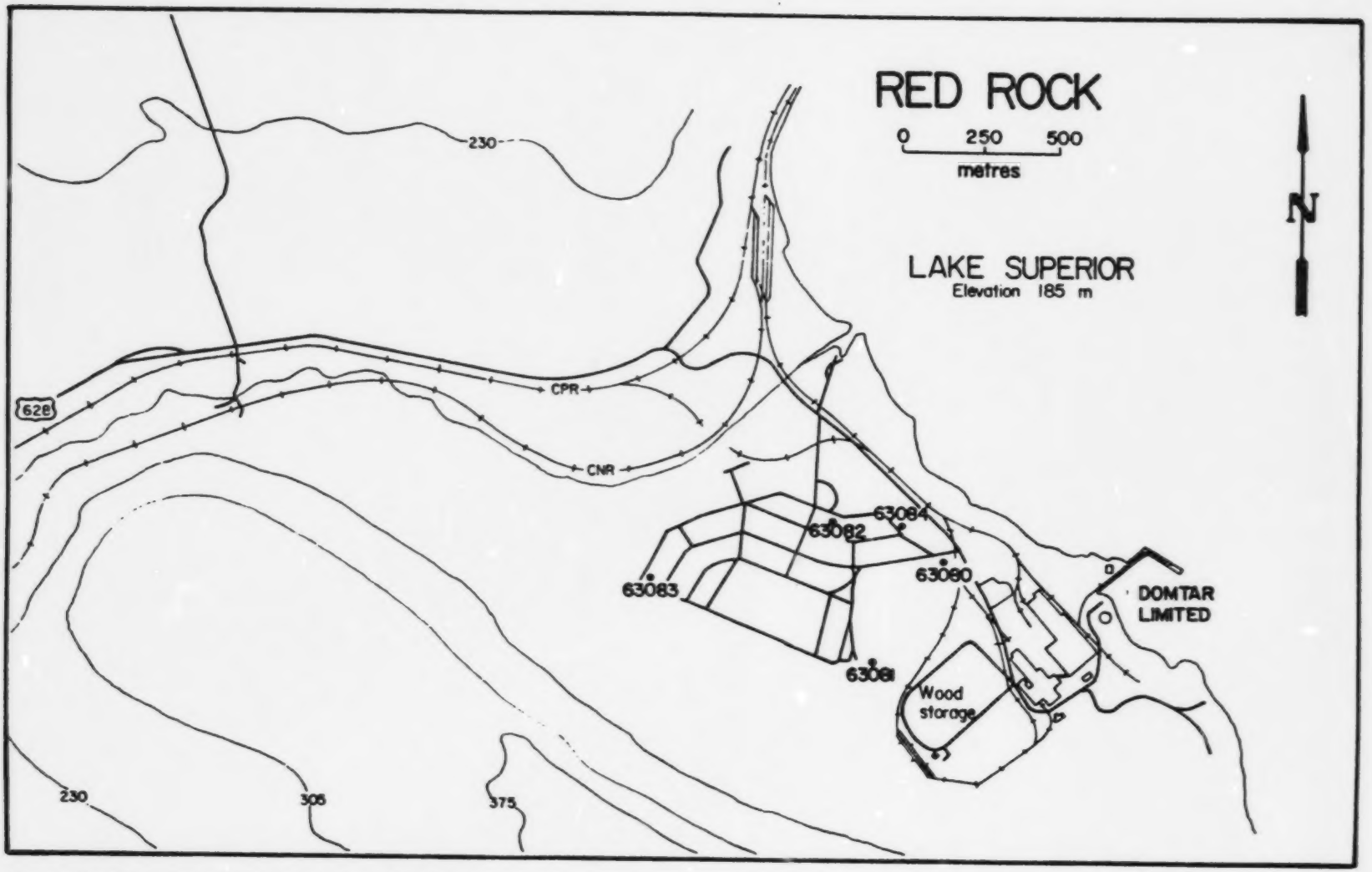

Figure 10. Air quality monitoring sites, Red Rock.

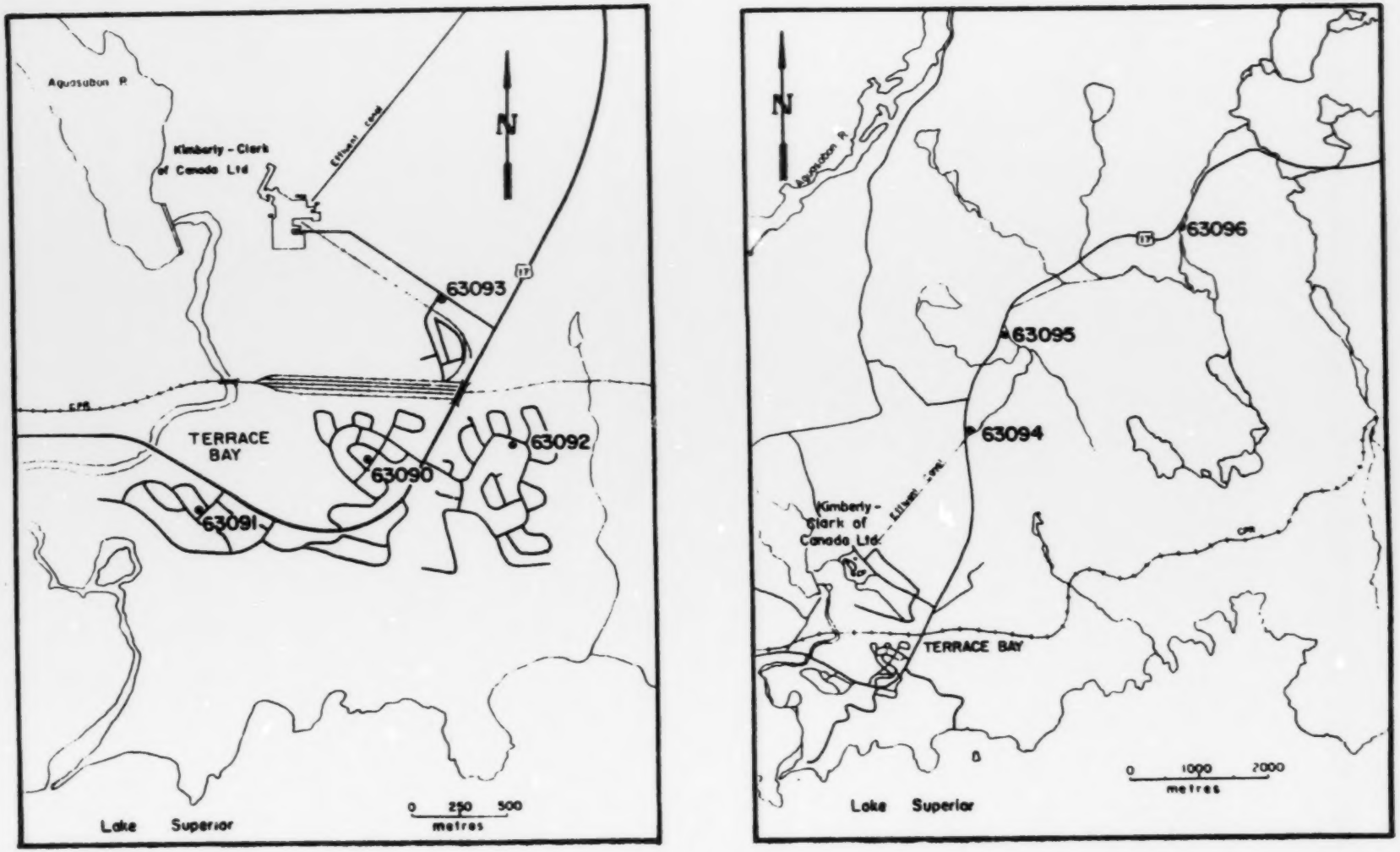

Figure II. Air quality monitoring sites, Terrace Bay.

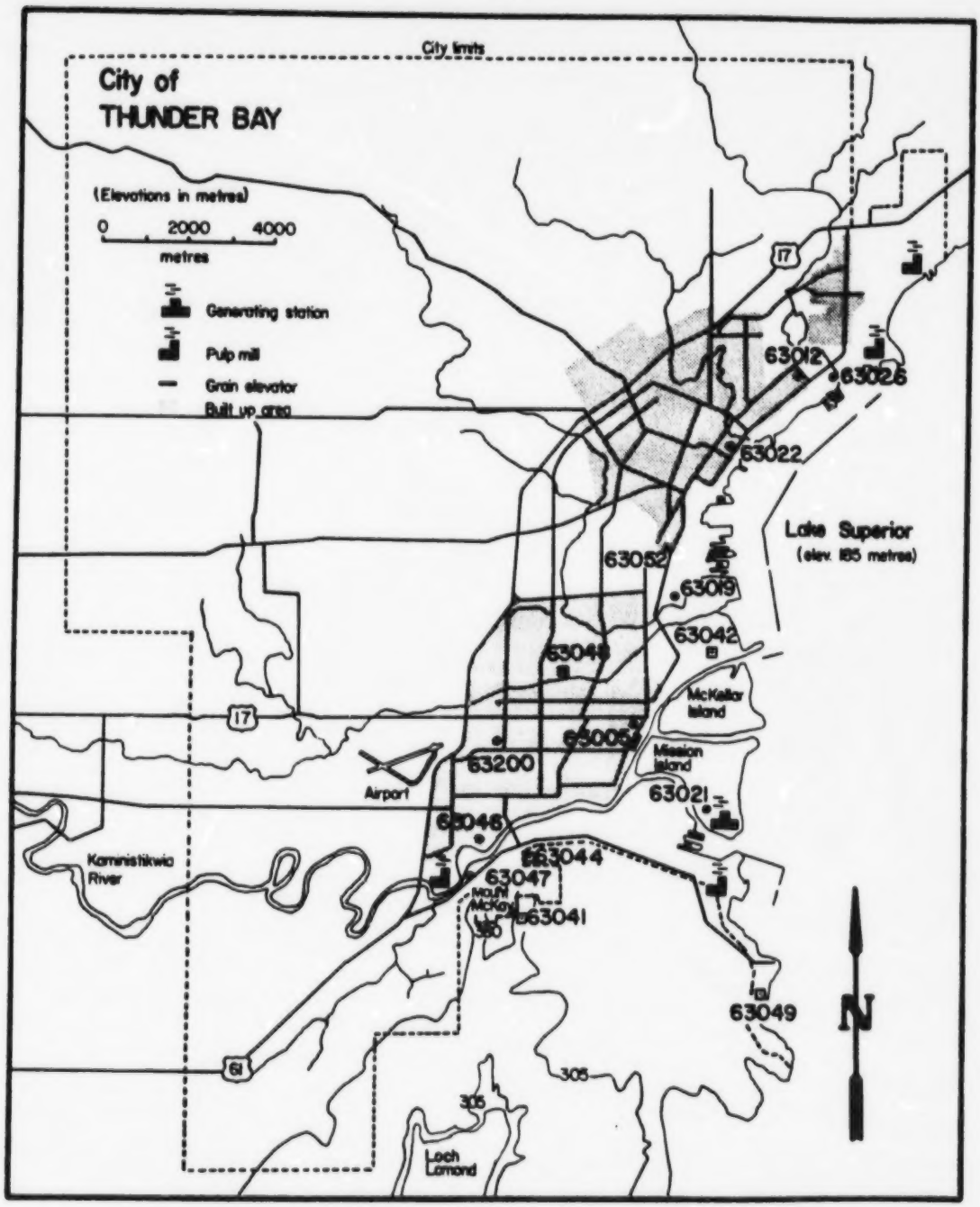

Figure 12. Air quality monitoring sites, Thunder Bay.

(⊡ Ontario Hydro sites)

TABLE 1. Arsenic content (μg/g, dry weight) of trembling aspen foliage, Balmertown, 1984-88.

Site[a]	1984	1985	1986	1987	1988
1	4	4	6	19	6
2	6	6	8	52	9
5	11	16	23	24	13
6	14	13	28	15	24
7	3	4	6	4	3
9[c]	7	6	6	7	5
11	3	13	4	11	7
12[c]	4	2	1	5	3
13	31	90	160	140	230
14	17	23	75	20	42
17	6	22	13	11	17
20[c]	14	5	2	11	7
21[c]	3	6	2	6	4
23	12	16	15	<1	7
24[c]	6	11	5	18	5
28	60	74	180	150	33
32	17	55	32	61	36
Controls	<1	<1	<1	<1	<1

[a] Shown in Figure 2.
[b] Values above guideline (2 μg/g) are underlined.
[c] Sites in townsite area.

TABLE 2. Average arsenic content (μg/g, dry weight) of foliage from planted roadside Manitoba maple (Acer negundo) and white elm (Ulmus americana) trees, Balmertown, 1984-88.

Site	1984	1985	1986	1987	1988
Dickenson & Mine Rd.	8	12	26	18	18
Balmertown public school	4	6	4	14	8
Fifth St. & Mine Rd.	3	5	12	10	7
Control (Red Lake)	<1	<1	<1	<1	<1

TABLE 3. Average arsenic levels (μg/g, dry weight) in washed vegetables and surface soil (0-5 cm) from Balmertown gardens[a], 1984-88.

Sample	1984	1985	1986	1987	1988
	Balmertown				
Potato leaves[b]	11	14	6	10	9
Potato tubers	<1	<1	<1	<1	<1
Beet leaves	5	2	3	3	2
Beet roots	3	1	1	<1	<1
Lettuce leaves	20	9	6	7	6
Garden soil	82	90	96	56	24
Lawn soil	230	180	230	190	77
	Red Lake				
Potato leaves[b]	1	1	2	<1	<1
Potato tubers	<1	<1	<1	<1	<1
Beet leaves	<1	<1	<1	<1	<1
Beet roots	<1	<1	<1	<1	<1
Lettuce leaves	<1	1	<1	<1	3
Garden soil	8	7	6	5	5
Lawn soil	10	9	8	8	4

[a] Two gardens from 1984 to 1987, one garden in 1988.
[b] Unwashed.
[c] Values above contaminant guidelines (2 μg/g for vegetation, 10 μg/g for soil) are underlined.

TABLE 4. Summary of sulphur dioxide data, Balmertown, 1984-88.

Year	Days of data	Annual ave. (ppm)	Annual exceedences		Growing season exceedences	
			Hours	Days	Hours	Days
1984	365	0.005	50	2	21	1
1985	341	0.010	114	3	61	2
1986	355	0.008	79	2	28	1
1987	332	0.010	87	7	23	1
1988	353	0.008	53	2	19	nil

TABLE 5. Summary of concentrations (ppb) of total reduced sulphur, Dryden, 1984-88.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1984	327	1.1	187	28
1985	340	1.0	51	17
1986	352	1.0	77	12
1987	346	0.5	26	nil
1988	323	0.4	45	1

TABLE 6. Average chloride and sodium concentrations in unwashed Manitoba maple foliage, Fort Frances-International Falls, 1980, 1984, and 1988.

	Chloride(%, dry weight)			Sodium(μg/g, dry weight)		
Site[a]	1980	1984	1988	1980	1984	1988
1[b]	1.20	0.26	0.21	1800[d]	1200	410
2[b]	0.81	0.21	0.12	1400	970	200
3[b]	0.87	0.19	0.11	1200	530	90
4[b]	0.71	0.13	0.20	620	350	110
5	0.35	0.13	0.27	260	620	120
6	0.36	0.16	0.28	390	650	240
9	0.22	0.16	0.08	150	320	130
13	0.04	0.03	0.02	83	66	160
14[c]	0.08	0.08	0.09	53	270	280
16[c]	0.53	0.10	0.15	73	640	440
18	0.21	0.09	0.13	120	150	85
20	0.10	0.07	0.05	250	150	70
21	0.15	0.10	0.15	250	54	75
22	0.13	0.07	0.07	240	190	190
23	0.26	0.06	0.11	280	210	75
24	0.42	0.09	0.08	210	160	95
25	0.17	0.08	0.12	410	150	90
28		0.11	0.21		270	130
Controls	0.10	0.06	0.06	100	84	95

[a] See Figure 6 for site locations.

[b] Sites on company property.

[c] U.S. sites.

[d] Values above contaminant guideline (350 μg/g) for sodium in vegetation are underlined.

TABLE 7. Average annual dustfall ($g/m^2/30$ d), Fort Frances, 1988.

Monitoring sites[a]	Total dustfall	Insoluble dustfall	Saltcake in dustfall
62032	2.8	1.5	0.3
62033[b]	8.8[c]	4.0	2.5
62034	5.6	3.8	0.7
62035	8.0	4.6	1.4
62036	9.7	6.2	1.3
62037	3.0	1.6	0.4
62046[b]	13.3	8.6	1.7
62050	7.5	4.1	1.3
Average, sites off mill property	6.1	3.6	0.9
% of total dustfall, off property sites		59	15

[a] See Figure 6.
[b] Sites on company property.
[c] Values above the maximum acceptable limit (4.6 $g/m^2/30$ d) are underlined.

TABLE 8. Average annual dustfall ($g/m^2/30$ d) at six Fort Frances monitoring sites off mill property, 1984-88.[a] Percentages of total dustfall are shown in parentheses.

Parameter	1984	1985	1986	1987	1988
Total dustfall	8.3	8.3[b]	7.1	5.9	6.1
Insoluble dustfall	5.2(63)	4.9(59)	3.8(54)	3.1(52)	3.6(59)
Saltcake in dustfall	1.5(18)	0.8(10)	1.4(20)	1.1(19)	0.9(15)

[a] Stations 62030/35, 62032, 62034, 62036, 62037, and 62050.
[b] Insufficient data for station 62050.

TABLE 9. Average annual sulphation rates (mg SO_3/100 cm^2/d), Fort Frances, 1984-88.

Station	Location	1984	1985	1986	1987	1988
62032	Cemetery	0.08	0.07	0.07	0.08	0.10
62033	Nelson/Portage	0.17	0.14	0.17	0.17	0.14
62034	First/Victoria	0.06	0.07	0.06	0.05	0.06
62035	Legion Building	0.10	0.11	0.10	0.09	0.09
62036	Sinclair/Victoria	0.06	0.08	0.06	0.07	0.08
62037	Reid/Gillon	<0.05	0.05	<0.05	<0.05	<0.05
62046	Sinclair/Portage	0.13	0.10	0.10	0.09	0.09
62047	Eighth/Cornwall	0.12	0.13	0.11	0.09	0.11
62049	Sixth/Portage	<0.05	0.06	0.06	0.06	<0.05
	AVERAGES	0.09	0.09	0.08	0.08	0.08

TABLE 10. Summary of total reduced sulphur concentrations (ppb) at stations 62030, 62052 and 62032, Fort Frances, 1976-1988.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
	Station 62030/62052			
1976[a]	309	12.8	458	916
1977[a]	294	15.4	480	969
1978[a]	304	16.1	540	1035
1979[a]	344	10.2	353	911
1980[a]	352	9.3	499	872
1981[a]	277	12.0	279	806
1982[a]	320	8.8	543	685
1983[b]	336	4.9	254	418
1984[b]	332	2.8	98	135
1985[b]	363	2.0	191	87
1986[a,b]	335	3.9	226	300
1987[a]	359	5.5	278	431
1988[a,b]	359	5.9	268	552
	Station 62032			
1976	139	2.5	116	91
1977	225	3.3	129	176
1978	281	2.5	134	141
1979	306	2.9	140	178
1980	307	3.3	124	210
1981	271	3.1	211	202
1982	269	2.1	99	115
1983	309	2.8	87	180
1984	314	1.9	74	38
1985	363	1.1	61	28
1986	325	1.2	133	37
1987	345	1.8	215	61
1988	363	1.7	160	84

[a] Station 62030
[b] Station 62052

TABLE 11. Average annual dustfall ($g/m^2/30$ d), Kenora 1984-88.

Station[a]	Location	1984	1985	1986	1987	1988
61003	Fourth/Main	4.8	5.4	3.3	3.2	4.3
61007	Melick/Ninth	10.9	9.7	8.9	7.5	9.5
61008	Melick/Eleventh	3.3	5.6	3.1	3.0	5.9
61009	Third/Matheson	4.5	5.1	3.2	3.7	4.3
	Averages	5.9	6.4	4.6	4.3	6.0

[a] See Figure 8.

[b] Values exceeding maximum acceptable level of 4.6 are underlined.

TABLE 12. Average annual sulphation rates (mg $SO_3/100\ cm^2/d$), Kenora, 1984-88.

Station[a]	Location	1984	1985	1986	1987	1988
61003	Fourth/Main	0.05	0.07	0.09	0.12	0.13
61007	Melick/Ninth	0.07	0.06	0.09	0.10	0.13
61008	Melick/Eleventh	0.11	0.09	0.08	0.06	0.09
61009	Third/Matheson	<0.05	<0.05	<0.05	<0.05	<0.05
	Averages	0.06	0.06	0.07	0.08	0.10

[a] See Figure 8.

TABLE 13. Average annual sulphation rates (mg SO_3/100 cm^2/d), Marathon, 1984-88.

Station	Location	1984	1985	1986	1987	1988
63027	McLeod/Abrams	0.16	0.13	0.18	0.15	0.16
63029	Marathon Shell	[a]	0.10	0.08	0.06	0.07
63030	Howe/Yawkey	0.10	0.08	0.07	0.05	0.07
63032	Heron Bay	0.04	0.06	0.05	<0.05	0.05
63033	Water Tower	0.14	0.15	0.19	0.10	0.13
	Averages		0.10	0.11	0.08	0.10

[a] Insufficient data to calculate average.

TABLE 14. Summary of TRS concentrations (ppb) at station 63034, Marathon, 1984-88.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1984	329	1.0	71	22
1985	343	1.3	83	52
1986	316	2.1	131	115
1987	331	2.0	150	93
1988	327	2.2	67	109

TABLE 15. Average annual dustfall (g/m^2/30 d), Red Rock, 1984-88.

Station[a]	Location	1984	1985	1986	1987	1988
63080[b]	Rankin Street	9.0	6.8	5.9	6.2	5.3
63081	Stewart/Frost	5.9	4.5	4.4	4.8	4.7
63082	47 Timmins Street	7.0	4.9	4.6	5.2	5.9
63083	122 Brompton Road	2.1	3.0	2.6	2.8	2.9
	Averages	6.0	4.8	4.4	4.8	4.7

[a] See Figure 10.
[b] Site on company property.
[c] Values exceeding maximum acceptable limit of 4.6 are underlined.

TABLE 16. Summary cf TRS concentrations (ppb) at station 63084, Red Rock, 1984-88.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1984	365	1.3	111	23
1985	362	2.0	104	117
1986	317	1.9	80	87
1987	337	3.1	216	203
1988	350	2.8	201	173

TABLE 17. Average annual sulphation rates (mg/SO_3/100 cm^2/d), Terrace Bay, 1984-88.

Station[a]	Location	1984	1985	1986	1987	1988
63090	St. Martin School	0.08	0.12	0.10	0.08	0.11
63091	Ft. Garry Road	0.08	0.14	0.10	0.07	0.14
63092	Terrace Heights Dr.	0.06	0.08	0.06	0.06	0.08
63093	Mill Road	0.09	0.13	0.09	0.11	0.13
63094	Highway 17, #1	0.13	0.13	0.08	0.08	0.08
63095	Highway 17, #2	0.06	0.08	0.06	0.07	0.06
63096	Highway 17, #3	0.06	0.04	<0.05	<0.05	<0.05
	Averages	0.08	0.10	0.08	0.07	0.09

[a] See Figure 11.

TABLE 18. Summary of TRS concentrations (ppb) at station 63090, Terrace Bay, 1984-88.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1984	331	1.2	104	38
1985	364	1.4	200	67
1986	350	1.5	155	72
1987	316	2.4	159	121
1988	332	2.2	129	111

TABLE 19. Total dustfall ($g/m^2/30$ d), Thunder Bay, 1988.

Station[a]	Location	Monthly Min	Monthly Max	Annual average
63005	McKellar Hospital	1.1	6.9	3.5
63012	Dawson Court	0.4	6.2	2.9
63019	Main St. Pumping Station	0.9	14.4	3.7
63021	Mission Island	0.2	5.4	2.3
63022	St. Joseph's Hospital	0.8	6.9	3.4
63026	N. Cumberland Hydro	1.1	6.2	3.0
63046	Montreal Street	1.3	17.4	5.1
63047	Totem Trailer Court	1.7	15.0	6.5
63052	Thunder Bay Transit	0.5	16.6	4.5
63200	615 James St. South	0.4	4.9	2.4

[a] See Figure 12.
[b] Values exceeding maximum acceptable levels of 7.0 (monthly) or 4.6 (annual average) are underlined.

TABLE 20. Total suspended particulate matter ($\mu g/m^3$), Thunder Bay, 1988.

Station[a]	Number of samples	Annual geometric mean	Number of samples above 120 $\mu g/m^3$	Maximum 24-hour value
63005	56	37	nil	102
63012	57	34	1	126
63022	56	36	nil	97
63046	57	64[b]	11	644
63052	56	43	1	153
63200	58	37	1	129

[a] See Figure 12.
[b] Values exceeding the maximum acceptable limit of 120 $\mu g/m^3$ (24-hour average) or 60 $\mu g/m^3$ (annual geometric mean) are underlined.

TABLE 21. Summary of carbon monoxide, nitrogen dioxide and ozone concentrations (ppm), station 63200, Thunder Bay, and ozone at Hawkeye Lake, 1988.

	Maximum 1-hour average	Maximum 8-hour average	Maximum 24-hour average
Carbon monoxide	6.0	3.4	
Nitrogen dioxide	0.35		0.04
Ozone, Thunder Bay	0.077		
Ozone, Hawkeye Lake[a]	0.095		

[a] 40 km north-northwest of Thunder Bay

TABLE 22. Summary of sulphur dioxide concentrations (ppm) in Thunder Bay, 1988.

Station[a]	Location	Annual average	Maximum 1-hour average	Maximum 24-hour average
63022	St. Joseph's Hospital	<0.001	0.05	0.01
63200	615 S. James Street	<0.001	0.05	0.01
63041[b]	Mt. McKay		0.20	0.03
63042[b]	East End		0.03	<0.01
63044[b]	James St./Kam River		0.16	0.01
63048[b]	Ford Street		0.17	<0.01
63049[b]	Chippewa Park		0.09	0.01

[a] See Figure 12 for station locations.
[b] Ontario Hydro. 1988-89. Environmental Quality Compliance Reports, 1988. Technical and Training Services Division.

TABLE 23. Summary of total reduced sulphur concentrations (ppb), station 63046[a], Thunder Bay, 1984-1988.

Year	Days of data	Annual average	Maximum 1-hour average	Number of times above guideline
1984	164	0.6	22	nil
1985	286	0.8	27	nil
1986	337	1.0	55	4
1987	329	0.8	52	12
1988	361	1.0	36	5

[a] See Figure 12 for station location.